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RD INSTRUMENTS

FOR RESEARCH AND DEVELOPMENT

INSTRUCTION MANUAL

for

MODEL 1715A SQUARE WAVE GENERATOR

THE HICKOK ELECTRICAL INSTRUMENT COMPANY · 10514 Dupont Avenue, Cleveland 8, Ohio

HICKOK—P-3084

INSTRUCTION MANUAL

for

MODEL 1715A SQUARE WAVE GENERATOR

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HICKOK ELECTRICAL INSTRUMENT COMPANY

CLEVELAND, OHIO

2490-434 12/62

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This warranty is in lieu of all other warranties expressed or implied, and no representative or person is authorized to assume for us any other liability in connection with the sale of our products.

Parts will be made available for a minimum period of five years after the manufacture of this equipment has been discontinued. Parts include all materials, charts, instructions, diagrams, accessories, etc., which have been furnished in the standard model.

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REGISTRATION CARD

The above guarantee is contingent upon the attached registration card being returned to the factory immediately upon receipt of the equipment.

THE HICKOK ELECTRICAL INSTRUMENT COMPANY
Cleveland, Ohio

75 OHM
ATTENUATOR
40 DB
20 DB
60 DB
0 DB
FREQUENCY
RANGE
SELECTOR
X100
X1K
X10
X10K
X1
SYMMETRY
OUTPUT AMPLITUDE
75 OHM
OUTPUT AMPLITUDE
600 OHM
INSTRUMENTS
SQUARE WAVE GENERATOR
MODEL 1715A
OUTPUT
75 OHM
SYNC.
INPUT
ON
PILOT
OUTPUT
GND.
600 OHM
THE HICKOK ELECTRICAL INSTRUMENT CO. CLEVELAND, OHIO, U. S. A.

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SECTION I - DESCRIPTION

1.1 Purpose

The Model 1715A is a wide range (1 cps to 1mc) square wave generator. It is to be used with an oscilloscope to determine the frequency response and phase shift characteristics of video and audio amplifiers. Amplifier gain measurements may also be made with this equipment.

1.2 Description

The generator is self contained in an aluminum case with a carrying handle located in a recessed area on the top of the unit. The wrap-around sides are easily removed for maintenance.

All operating controls are located on the front panel (Figure 1). Individual connectors are provided for 75 ohm output, 600 ohm output, and the external synchronizing (sync) input connections.

The test applications of the signal generator require the use of other equipment. An oscilloscope is required for visual display of test results. A source of external synchronizing signal voltages, such as an audio oscillator, is necessary in certain types of operation to trigger the sync input circuit of the signal generator.

1.3 Technical Characteristics

	Frequency Range
X1	1 to 10 cps
X10	10 to 100 cps
X100	100 to 1000 cps
X1K	1KC to 10KC
X10K	10KC to 100KC
X100K	100KC to 1MC

Types of output:

Low impedance output	7.0 volts, peak to peak 75 ohms internal impedance 0.02 microsecond rise time
Output connector	Type BNC
High impedance output	55 volts peak to peak 600 ohms internal impedance .1 microsecond rise time
Output Terminals	Dual banana jack

Sync Input	Requires positive-going signal pulse or sine wave.
Recommended Peak Amplitude of Sync Input Signal	5 volts
Min. Sync. Signal	3 volts
Type of Input Connector	BNC

Power Supply Requirements:

Line voltage input	115 volts A. C. - 50 to 60 cycles
Power consumption	210 watts

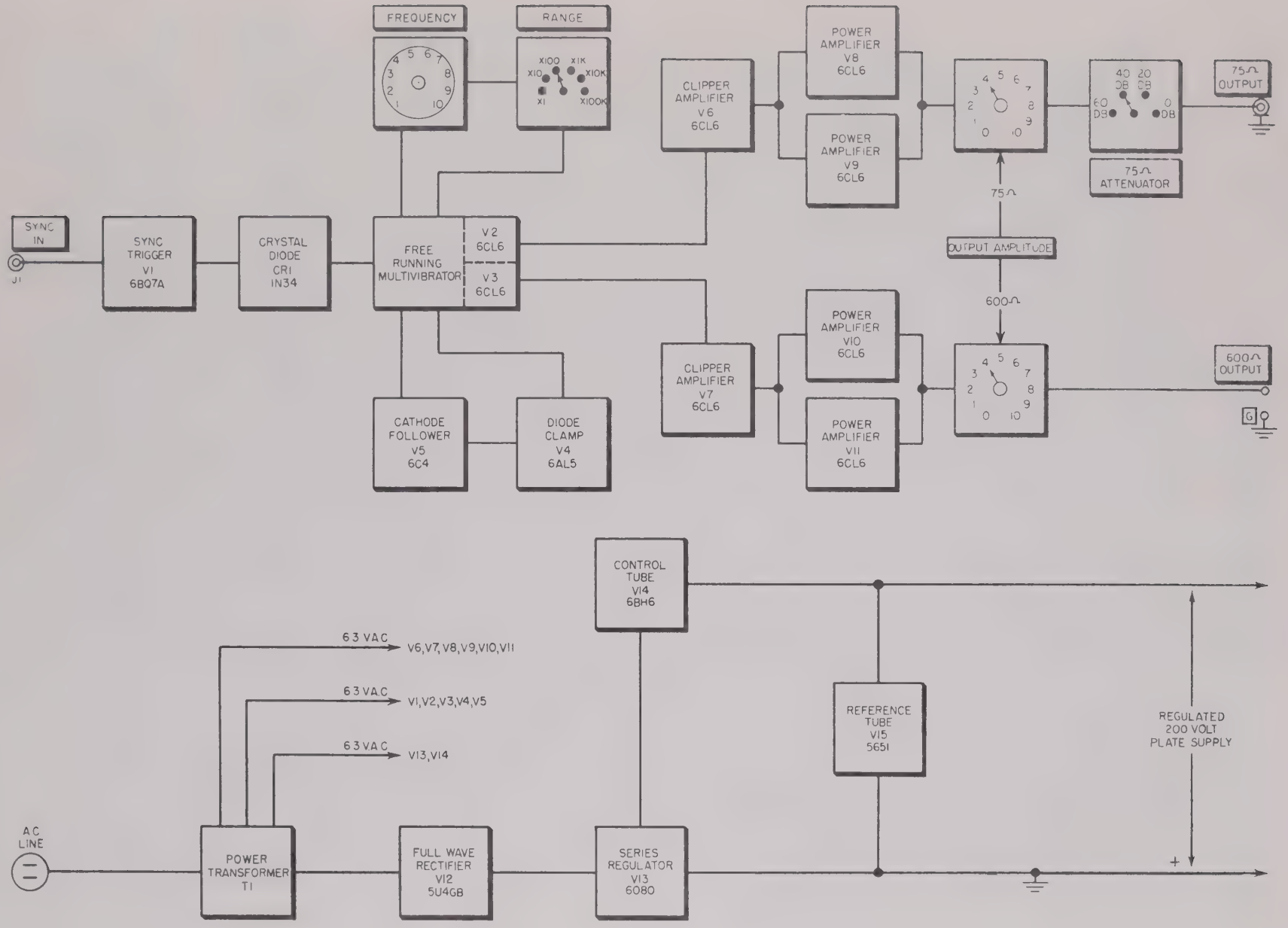


Fig. 2 - Block Diagram

SECTION II - THEORY

2. 1 General

The Model 1715A is a wide range square wave generator to be used with an oscilloscope for testing audio and video amplifiers. It consists of a free-running plate-coupled multivibrator which produces a square-wave output signal. The frequency of the multivibrator may be adjusted from 1 cycle to 1 megacycle per second. The square wave output of the multivibrator is fed to a push-pull clipper amplifier stage which in turn feeds a power stage consisting of four tubes connected in push-pull parallel.

The power amplifier stage is terminated in two separate output systems, 75 and 600 ohms. The 75 ohm output is adjusted by a variable amplitude control and a 60 db four-step constant impedance attenuator network. The 600 ohm output is adjusted by a two-section balanced-amplitude control. The two outputs can be used separately or simultaneously. A trigger circuit coupled to the multivibrator permits synchronization of the signal generator with an external signal source. To maintain stable operation of the generator, plate voltage for the various circuits is supplied by a regulated power supply designed to maintain a constant d.c. output voltage over line voltage variations from 105 volts to 125 volts A. C. , 50 to 60 cycles. The block diagram, Figure 2, is presented to aid in the use and maintenance of the generator.

2. 2 Multivibrator (See Figure 3)

The multivibrator in the signal generator uses two 6CL6 tubes connected in an RC plate-coupled multivibrator circuit. Capacitors CX1 and CX2 provide coupling between the two sections of the multivibrator and, in conjunction with grid resistors RX1, RX2, and RX3, comprise a timing network which determines the range of multivibrator frequency. The values of these components are changed for each frequency range by the Range switch.

2. 3 Frequency control (See Figure 3)

The frequency control, R9, provides a variable grid return voltage which permits a frequency variation on each range of 10 to 1. The diode clamp circuit consisting of V4 and V5, limits the peak voltage applied to the grids of V2 and V3 and improves the square-wave output from the multivibrator.

Symmetry control, R17, balances the periods of conduction from the two halves of the multivibrator.

2. 4 Sync Trigger (See Schematic Figure 5)

When synchronization is required an external sync signal is fed into Sync In jack. Application of a positive going pulse of at least a 3 volt peak is amplified and shaped and then coupled thru crystal diode CR1 to the plate of V2, thereby providing synchronization for the multivibrator with an external signal voltage.

2. 5 Clipper Amplifier (See Schematic Figure 5)

The output of multivibrator tubes V2 and V3 is coupled thru capacitors C19 and C28 to provide a push-pull driving signal for the two 6CL6 clipper amplifier tubes V6 and V7. This push-pull signal from the multivibrator drives the clipper amplifier alternately into cutoff and saturation, thereby producing amplified, square-topped, output signals at the plates of V6 and V7.

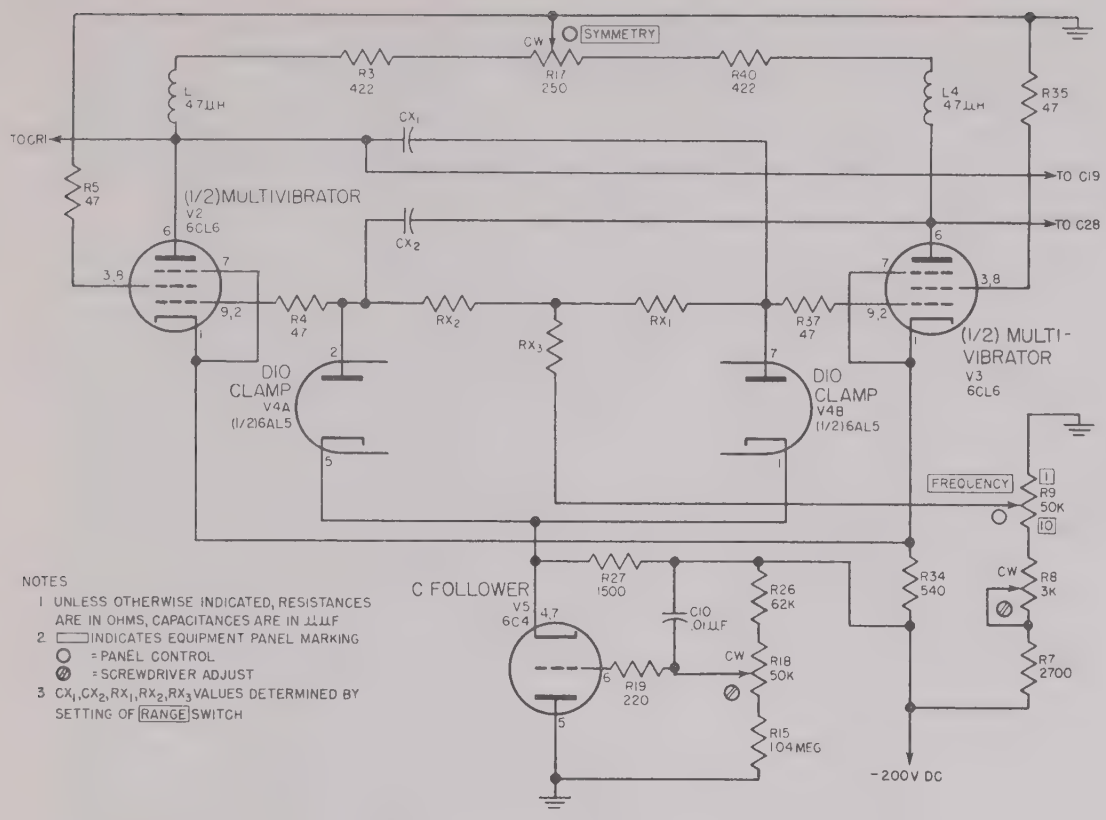


Fig. 3 - Simplified Multivibrator Circuit

2.6 Power amplifier (See Schematic Figure 5)

The power amplifier consists of four type 6CL6 pentodes connected in push-pull parallel. The outputs from the clipper amplifiers, V6 and V7, are 180° out of phase with each other, therefore one half of the output amplifier is conducting, while the other half is cut off. Each half of the push-pull parallel power amplifiers is connected to a separate output system. The output of V8 and V9 is connected to the 75 ohm output Amplitude Control. The output of V10 and V11 is connected to the 600 ohm Output Amplitude control.

2.7 Attenuator circuits (See schematic, Figure 5)

The 75 ohm output Amplitude control R51 adjusts the voltage input to the 75 ohm Attenuator control. This attenuator control is a three-section pi-type attenuator, each section introducing a 20 decibel (db) loss when switched into the circuit. The switch has four positions. In the first position, the 75 ohm Output Amplitude control is connected directly to 75-ohm jack, J2.

The 600 ohm Output Amplitude control, R84A, and R84B, adjusts the voltage level at the 600 ohm output connector, J3.

2.8 Power Supply (See schematic, Figure 5)

To insure proper operation of the signal generator, it is essential that all DC voltages are regulated and free from ripple or noise. Special regulating features are therefore included in the power supply circuit.

Power transformer, T1, supplies all of the necessary AC voltages for the operation of

the signal generator. The primary of the power transformer consists of two windings, normally wired in parallel for 115-volt operation. When 230-volt operation is required, the dual primaries are wired in series. The AC line voltage from P1 is fed through power switch S3 and fuse F1 to the dual primaries of T1. A type 5U4GB full wave rectifier tube, V12, fed by the high voltage winding of the transformer, provides an unregulated DC output voltage which is then filtered by C31. The negative B supply is connected directly to the load, and the positive side of the load is connected directly to the chassis.

Regulation is accomplished by means of a series type regulator, V13, connected between the positive output of the unregulated supply and the chassis. The series regulator tube, V13, is controlled by a direct-coupled pentode control amplifier, V14. The cathode of V14 is referenced to the -200 volt regulated line through a reference tube, V15. The grid of the control tube is referenced to a point on a voltage divider between the chassis and the -200 volt regulated line. Any change in potential of the -200 volt line is expressed as a change in bias of the control tube V14 which causes the plate potential of the control tube to change. The plate of the control tube is connected directly to the control grids of the series regulator tube, V13. Any change of plate potential of the control tube causes a corresponding bias change in the series regulator tube. The operating level of the -200 volt supply may be set to the proper value by means of R95, the bias adjustment for the control tube, V14. Any tendency for the -200 volt regulated supply to become less negative causes the bias of the control tube, V14, to increase, thereby causing the control tube to conduct less, permitting the plate of the control tube to go more positive. The grids of the regulator tube, V13, are thus made more positive, causing the regulator tube to conduct more easily, thereby restoring the -200 volt regulated line to the correct value.

Should the -200 volt regulated line have a tendency to become more negative, reaction would be the opposite of that just described and the -200 volt regulated line would accordingly tend to remain at a constant level, determined by the initial setting of the voltage adjustment control, R95. When the proper output voltage of -200 volts has been established, the regulating control circuits will maintain this voltage constant over a line voltage range of 105 to 125 volts AC. The positive side of the regulated power supply is connected to chassis ground. This permits direct coupling between the output amplifier plates and the output jacks.

SECTION III - OPERATION

3.1 General

a. Two types of operation are possible with the signal generator: free running and synchronized.

1. Free running. The internal multivibrator operates at a frequency determined by the frequency dial setting and the range switch.

2. Synchronized. The internal multivibrator operates at a frequency determined by an external signal applied to the Sync In connector.

b. Two individual outputs are provided by the signal generator--the 600 ohm and the 75 ohm outputs. Each output is available across its respective output jack. It is possible to use these outputs either individually or simultaneously, and with either type of operation--free running or synchronized.

c. To prepare the signal generator for operation, proceed as follows:

1. Connect the line cord plug to a power source of 115 volts AC at 50/60 cycles per second.

2. Set the power switch to the ON position.

3. After a warm-up period of approximately 15 minutes, the generator is ready for operation.

3.2 Operating Procedure

a. Free running.

1. Set RANGE selector switch to the desired range of frequencies.

2. Adjust the FREQUENCY dial to the desired frequency of operation.

NOTE: The FREQUENCY dial is divided into 10 main divisions numbered 1 through 10. These main divisions are divided into five equal subdivisions. The dial reading under the index line multiplied by the number indicated by the RANGE selector gives the frequency of operation in cycles per second.

3. Connect the signal generator to the vertical input of an oscilloscope. Either the 75-ohm output or the 600-ohm output may be used.

4. Adjust the SYMMETRY control of the signal generator for equal widths of pulses as viewed on the oscilloscope.

5. The signal generator is now ready for free running operation.

b. Synchronized.

1. Connect the desired synchronizing signal to the SYNC IN connector of the signal generator.

2. Set the RANGE selector to the range which includes the frequency of the synchronizing input signal.

3. Adjust the FREQUENCY dial to a value slightly below the frequency of the synchronizing input signal.

4. Proceed in the same manner as outlined in 2 through 4 of free running operation.

c. Impedance Matching

1. When operating into a high impedance load, such as the grid circuit of an amplifier, the output may be taken from either the 75-ohm or the 600-ohm output connector without noticeable effect on the wave shape or on the 75-ohm attenuator calibration.

2. When operating from the 75-ohm output, into a relatively low impedance and a 75-ohm cable is used (A, fig. 4), the load impedance must be matched to the generator output impedance. To determine the value of the impedance matching network use the formula $Z_0 = Z_1 \ Z_2$.

3. When the connecting cable has an impedance greater or lower than 75-ohms, the impedance of the cable must be matched to the signal generator output impedance. Typical values for matching the cable impedance to the generator are shown in B and C of Figure 4.

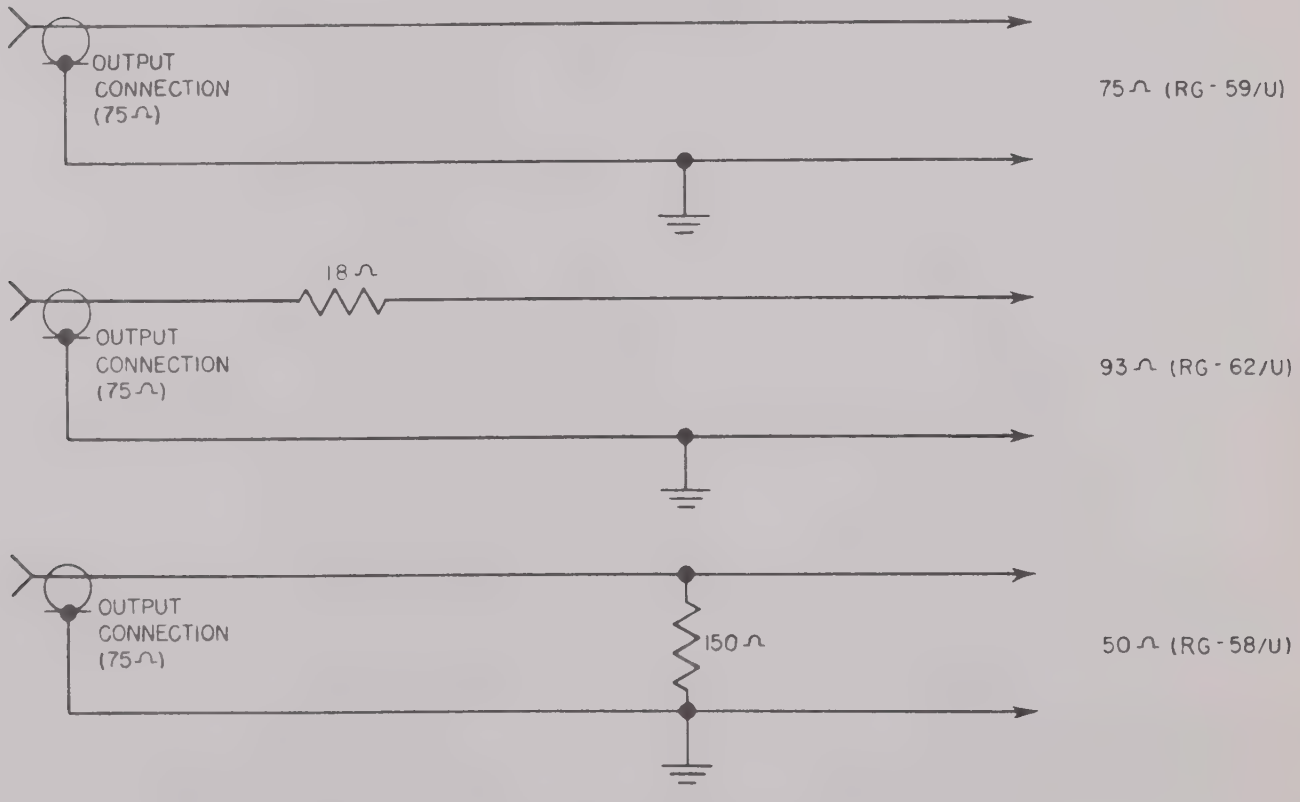


Fig. 4 - Typical Impedance Matching Networks

SECTION IV - MAINTENANCE

4. 1 General

The Model 1715A is built in accordance with sound engineering principles, by skilled personnel using quality components. Normally, routine replacement of tubes will be the only field maintenance necessary. Should the need arise for more extensive maintenance, it is suggested that the factory be contacted with regard as to the nature of the trouble, and, if necessary, the unit be returned to the factory or an authorized Hickok repair station for inspection and service. A schematic, Figure 5, and a block diagram, Figure 2, are given to aid in maintenance work.

Access to the interior of the instrument may be had by removing the retaining screws located at the lower end of the front and rear trim strips.

The trim strips may then be spread apart slightly and removed. This permits removal of the wrap-around sides, exposing the chassis for inspection and maintenance.

4. 2 Tube replacement

Replacement of V2, V3, V4, V5, V13, V14, or V15, may necessitate some degree of readjustment of the generator. In the event of tube failure, tubes used for replacement should be aged in position at least 24 hours before final recalibration.

4. 3 Power Supply Adjustment

Proper operation of the signal generator depends upon correct functioning of the power supply circuit. Variations in the power supply will cause the multivibrator circuit to drift off calibration and cause erratic operation in the other circuits. Whenever the signal generator is suspected of inaccurate or marginal operation, before attempting any other service work, check the power supply circuits for proper output voltage. Connect an accurate voltmeter between the chassis and the -200 volt regulated line. With the equipment operating, -200 volts dc should be indicated.

4. 4 Frequency Calibration

a. The basic calibration of the multivibrator circuit is made at 1,000 cps by adjusting potentiometer R18. This initial adjustment is made at X100 on the RANGE switch with the FREQUENCY dial set at 10. Resistor R8 is then adjusted with the FREQUENCY dial set at 1 to establish the proper resistance-capacitance (RC) time constant at the lower frequency of 100 cps. The other ranges are calibrated by adjusting the timing network (b) below. All other ranges are referenced to range of X100 which must, therefore, be calibrated first. In most cases recalibration at X100 on the RANGE switch is the only adjustment necessary after replacing V2, V3, V4, or V5 in the multivibrator circuit. Proceed as follows:

   1. Set the FREQUENCY dial of the signal generator at 10 and the RANGE switch to X100.

   2. Connect the signal generator, oscilloscope, and audio oscillator.

   3. Set the audio oscillator for a frequency of 1,000 cps.

4. Adjust R18 until the pattern obtained on the oscilloscope screen indicates a frequency of 1,000 cps.

5. Set the FREQUENCY dial of the signal generator at 1.

6. Set the audio oscillator for a frequency of 100 cps.

7. Adjust R8 until the pattern obtained on the oscilloscope screen indicates a frequency of 100 cps.

8. Alternate between 1,000 cps and 100 cps until the frequency is correct at both ends of the dial.

b. RANGE Switch Calibration.

If it should be necessary to recalibrate any of the ranges other than X100, the following procedures apply. The test setup is similar to that for the range of X100 ("a" above).

Step No.	Set RANGE switch to	Set FREQUENCY dial to	Adjust Control symbol	Adjust to frequency of
1	X100	10	R18	1 kc
2	X1K	10	R23	10 kc
3	X10K	5	R24	50 kc
4	X100K	5	R25	500 kc
5	X10	1	R21	10 cps
6	X1	1	R20	1 cps

4.5 Sync Sensitivity Adjustment.

When no signal is applied to the input section of trigger tube V1, it is biased approximately 3 volts below cutoff. Therefore, an input signal in excess of 3 volts peak is required to operate the sync circuit. Adjust the sync circuit as follows:

1. Set the Frequency dial to 9.8 and the range switch to X100.

2. Connect a sine wave signal of 1000 cps with an amplitude of greater than 3.0 volts peak (2.2 volts root mean square (rms) to the Sync In connection.

3. Connect the output of the synchronizing voltage source to the Sync In jack of the Model 1715 and to the vertical input of an oscilloscope. Connect the output of the Model 1715 to the Horizontal Input of the oscilloscope. Adjust R39 until the oscilloscope presentation indicates synchronization.

PARTS LIST FOR MODEL 1715A

NOTE: There is a minimum billing charge of $3.00 for any one parts order. Prices will be furnished upon request.

Symbol Ref.	Name and Description	Hickok Code No.
	BOOKLET: Instructions	2490-344
J3	BINDING POST	2360-75
C1, 12	CAPACITOR: Fixed, paper, .22 μf, 10%, 400V	3105-233
C2, 13	CAPACITOR: Fixed, paper .1 μf, 5%, 600V	3105-234
C3, 14	CAPACITOR: Fixed, silver mica, .01 μf, 5%, 300V	3095-95
C4, 15	CAPACITOR: Fixed, silver mica, 1000 μμf, 1%, 500V	3095-97
C5, 16	CAPACITOR: Fixed, silver mica, 200 μμf, 1%, 500V	3095-96
C6, 17	CAPACITOR: Fixed, silver mica, 39 μμf, 5%, 300V	3095-92
C7, 10, 11, 21, 25, 33,	CAPACITOR: Fixed, ceramic disc, .01 μf, 10%, 600V	3110-75
C8	CAPACITOR: Fixed, paper, .47 μf, 400V	3105-240
C9	CAPACITOR: Fixed, silver mica, 5 μμf, 10%, 300V	3095-91
C18, 30	CAPACITOR: Fixed, silver mica, 200 μμf, 5%, 300V	3095-93
C19, 28	CAPACITOR: Fixed, paper, 2.0 μf, 400V	3105-235
C20, 22, 26, 27, 29	CAPACITOR: Fixed, silver mica, 15 μμf, 5%, 300V	3095-98
C23, 24	CAPACITOR: Fixed, silver mica, .001 μf, 5%, 300V	3095-94
C31	CAPACITOR: Fixed, electrolytic 20-20-40 μf, 450V	3085-83
C32	CAPACITOR: Fixed, paper .1 μf, 10%, 400V	3105-231
C34	CAPACITOR: Fixed, electrolytic, 20 μf, 450V	3085-84
L7	COIL: Filament	3320-143
L1, 4	COIL: RF, 4.7 microhenrys	3320-129
L2	COIL: RF, 6.8 microhenrys	3320-127
L3	COIL: RF, 500 microhenrys	3320-128
L5, 6	COIL: RF, .68 microhenrys	3320-132
J1, 2	CONNECTOR: coaxial, UG1094/U, type BNC	3475-78
P1	CORD: Line and plug assembly	3675-7
CR1	CRYSTAL: Sylvania IN34A	3870-2
F1	FUSE: 2.5 Amps, Slo-Blo	6900-25
DS1	LAMP: GE #47, .15 Amp. miniature bayonet base	12270-12
B1	MOTOR: Fan, Gen. Industries Model A-3-CW for horizontal shaft mounting	13750-3
R1	RESISTOR, fixed: composition, 2200 ohms, 10%, 2W	18432-222
R2	RESISTOR, fixed: composition, 4700 ohms, 10%, 2 W	18432-472
R3, 40	RESISTOR, fixed: 422 ohms, 1%, 1/2 watt	18537-109
R4, 5, 35, 37, 44, 46, 48, 49, 50, 52, 73, 76, 77, 78, 80, 83	RESISTOR, fixed: composition, 47 ohms, 10%, 1/2 W	18410-472
R6, 90	RESISTOR, fixed: composition, 100,000 ohms, 10%, 1W	18424-102
R7	RESISTOR, fixed: composition, 2700 ohms, 10%, 1 W	18422-272
R8	RESISTOR: variable 3,000 ohms, 10%, 1/2 watt, linear taper	16925-334
R9	RESISTOR: variable, 50,000 ohms, 5%, wire wound, 12 watt	16925-315
R10, 28	RESISTOR, fixed: 3.05 megohms, 1%, 1W	18539-22
R11, 29	RESISTOR, fixed: 683,700 ohms, 1%, 1W	18539-21
R12, 30	RESISTOR, fixed: 370,000 ohms, 1%, 1W	18539-20
R13, 31	RESISTOR, fixed: 216,500 ohms, 1%, 1W	18539-19
R14	RESISTOR, fixed: composition, 330,000 ohms, 10%, 1/2 watt	18414-332

PARTS LIST FOR MODEL 1715A

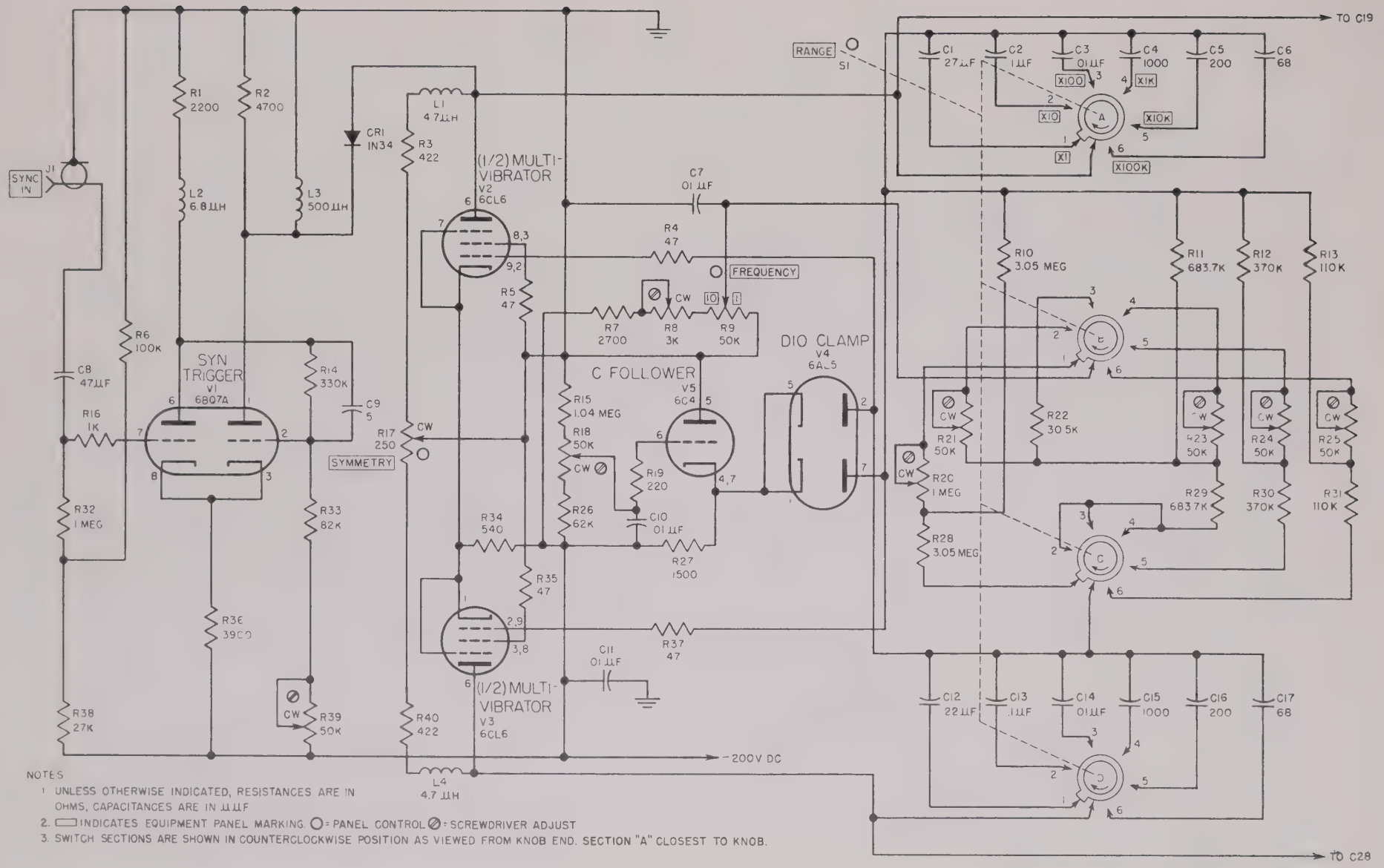
NOTE: There is a minimum billing charge of $3.00 for any one parts order. Prices will be furnished upon request.

Symbol Ref.	Name and Description	Hickok Code No.
R15	RESISTOR, fixed: 1.04 megohms, 1%, 1 watt	18539-28
R16	RESISTOR, fixed: composition, 1000 ohms, 10%, 1W	18422-102
R17	RESISTOR, variable: 250 ohms, 2W, linear taper 10%	40100-251
R18, 21, 23, 24, 25, 39	RESISTOR, variable: 50,000 ohms, linear taper, 1/2 watt, 10%	40300-503
R19	RESISTOR, fixed: composition, 220 ohms, 10%, 1/2 watt	18411-222
R20	RESISTOR, variable: 1 megohm, linear taper, 1/2 watt, 10%	40300-105
R22	RESISTOR, fixed: 30,500 ohms, 1%, 1 watt	18539-18
R26	RESISTOR, fixed: 62,000 ohms, 1%, 1 watt	18539-27
R27	RESISTOR, fixed: 1500 ohms, 1%, 1 watt	18539-26
R32, 54, 70	RESISTOR, fixed: composition, 1 megohm, 10%, 1/2 watt	18415-102
R33	RESISTOR, fixed: composition, 82,000 ohms, 10%, 1/2 W	18413-822
R34	RESISTOR, fixed: wire wound, 540 ohms, 5 watt, 10%	18575-192
R36	RESISTOR, fixed: composition, 3900 ohms, 10%, 2 watt	18432-392
R38	RESISTOR, fixed: composition, 27,000 ohms, 10%, 1 watt	18423-272
R41	RESISTOR, fixed: composition, 68,000 ohms, 10%, 1/2 watt	18413-682
R42, 43, 81, 82	RESISTOR, fixed: 2000 ohms, 1%, 2 watt	18540-7
R45	RESISTOR, fixed: composition, 82,000 ohms, 10%, 1 watt	18423-822
R47, 79	RESISTOR, fixed: 479,000 ohms, 1%, 1 watt	18539-25
R51	RESISTOR, variable: 75 ohms, 2 watt, linear taper, 10%	40100-750
R53, 58, 66, 69, 72, 75	RESISTOR, fixed: composition, 91 ohms, 5%, 1/2 watt	18410-911
R55, 71	RESISTOR, fixed: 230 ohms, 1%, 1 watt	18539-23
R56	RESISTOR, fixed: composition, 220,000 ohms, 10%, 1/2 W	18414-222
R57, 61, 63	RESISTOR, fixed: 470 ohms, 10%, 4 watt,	18575-191
R59, 68, 74	RESISTOR, fixed: composition, 360 ohms, 5%, 1 watt	18421-361
R60	RESISTOR, fixed: composition, 27,000 ohms, 10%, 1/2 W	18413-272
R62, 67	RESISTOR, fixed: 95,500 ohms, 1%, 1 watt	18539-24
R64	RESISTOR, fixed: composition, 270 ohms, 10% 1 watt	18421-272
R84A, 84B	RESISTOR, variable: 1200 ohms, dual, 2 W, linear taper, 10%	16925-311
R85	RESISTOR, fixed: composition, 120,000 ohms, 10%, 1W	18424-122
R86	RESISTOR, fixed: composition, 1 megohm, 10%, 1 watt	18425-102
R87	RESISTOR, wire wound: 800 ohms, 10%, 40 watt	18575-194
R88	RESISTOR, wire wound: 2000 ohms, 10%, 10 watt	18575-193
R89	RESISTOR, fixed: composition, 1000 ohms, 10%, 1/2 watt	18412-102
R91, 92	RESISTOR, fixed: composition, 47 ohms, 10%, 2 watt	18430-472
R93	RESISTOR, fixed: composition, 47,000 ohms, 10%, 1 watt	18423-472
R94	RESISTOR, fixed: composition, 330,000 ohms, 10%, 1 watt	18424-332
R95	RESISTOR, variable: 100,000 ohms, linear taper, 2 watt, 20%	16925-312
R96	RESISTOR, fixed: composition, 220,000 ohms, 10%, 1 watt	18424-222
R97	RESISTOR, fixed: composition, 18 ohms, 10%, 1 watt	18420-182
S1	SWITCH: rotary, 7 section, 6 position	19912-353
S2	SWITCH: rotary, 2 section, 4 positions	19912-354
S3	SWITCH: toggle, SPST	19911-63
T1	TRANSFORMER: power	20800-206
V1	TUBE: 6BQ7	20875-156

PARTS LIST FOR MODEL 1715 A

NOTE: There is a minimum billing charge of $3.00 for any one parts order. Prices will be furnished upon request.

Symbol Ref.	Name and Description	Hickok Code No.
V2, 3, 6, 7, 8, 9, 10, 11	TUBE: 6CL6	20875-105
V4	TUBE: 6AL5, RCA or GE	20875-51
V5	TUBE: 6C4	20875-62
V12	TUBE: 5U4GB	20875-141
V13	TUBE: 6080	20875-157
V14	TUBE: 6BH6	20875-153
V15	TUBE: 5651	20875-158



NOTES

1. UNLESS OTHERWISE INDICATED, RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN µµF
2. ▭ INDICATES EQUIPMENT PANEL MARKING. ○ = PANEL CONTROL ⊘ = SCREWDRIVER ADJUST
3. SWITCH SECTIONS ARE SHOWN IN COUNTERCLOCKWISE POSITION AS VIEWED FROM KNOB END. SECTION "A" CLOSEST TO KNOB.

Fig. 5-A Schematic Wiring Diagram

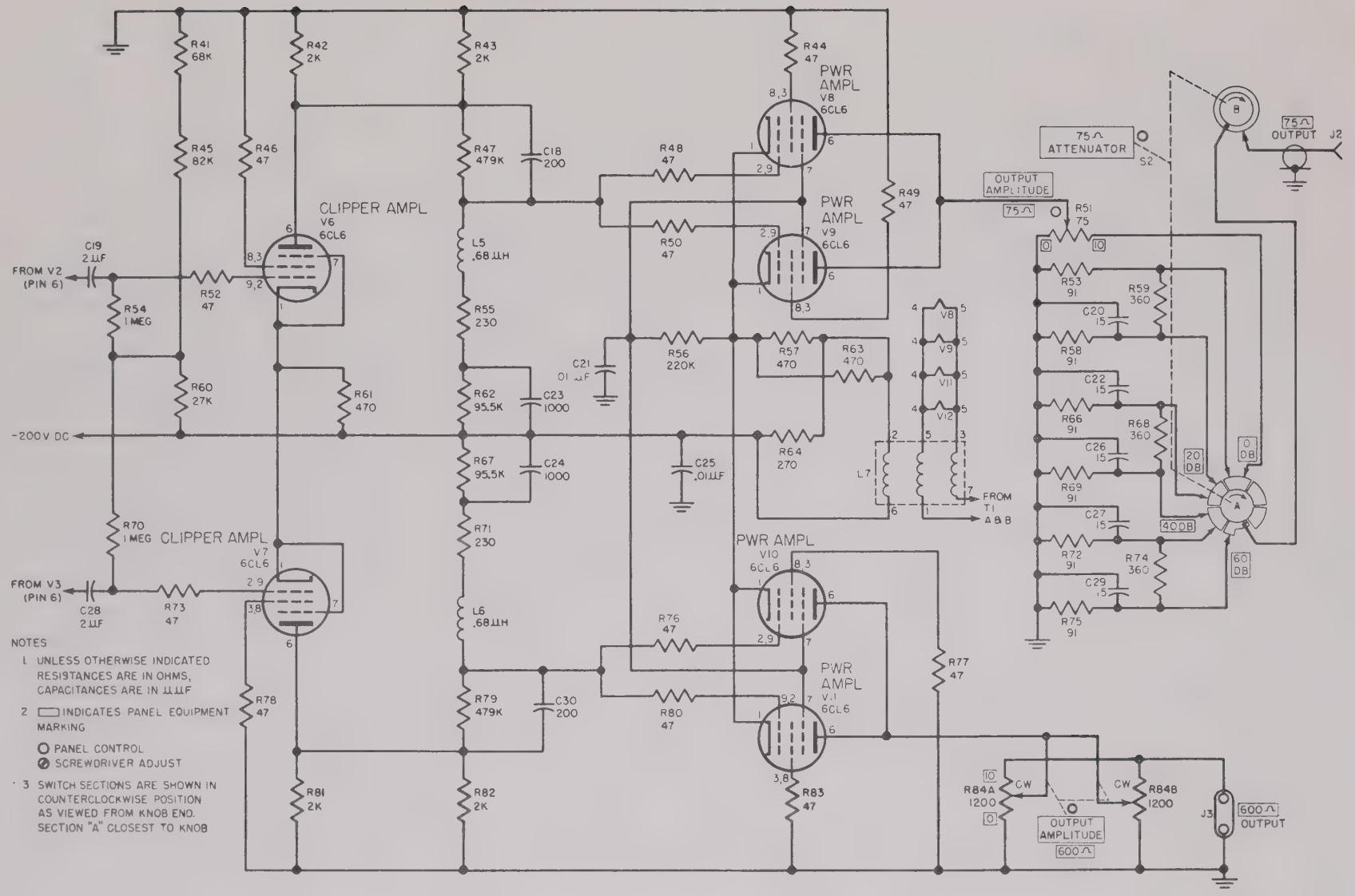


Fig. 5-B Schematic Wiring Diagram

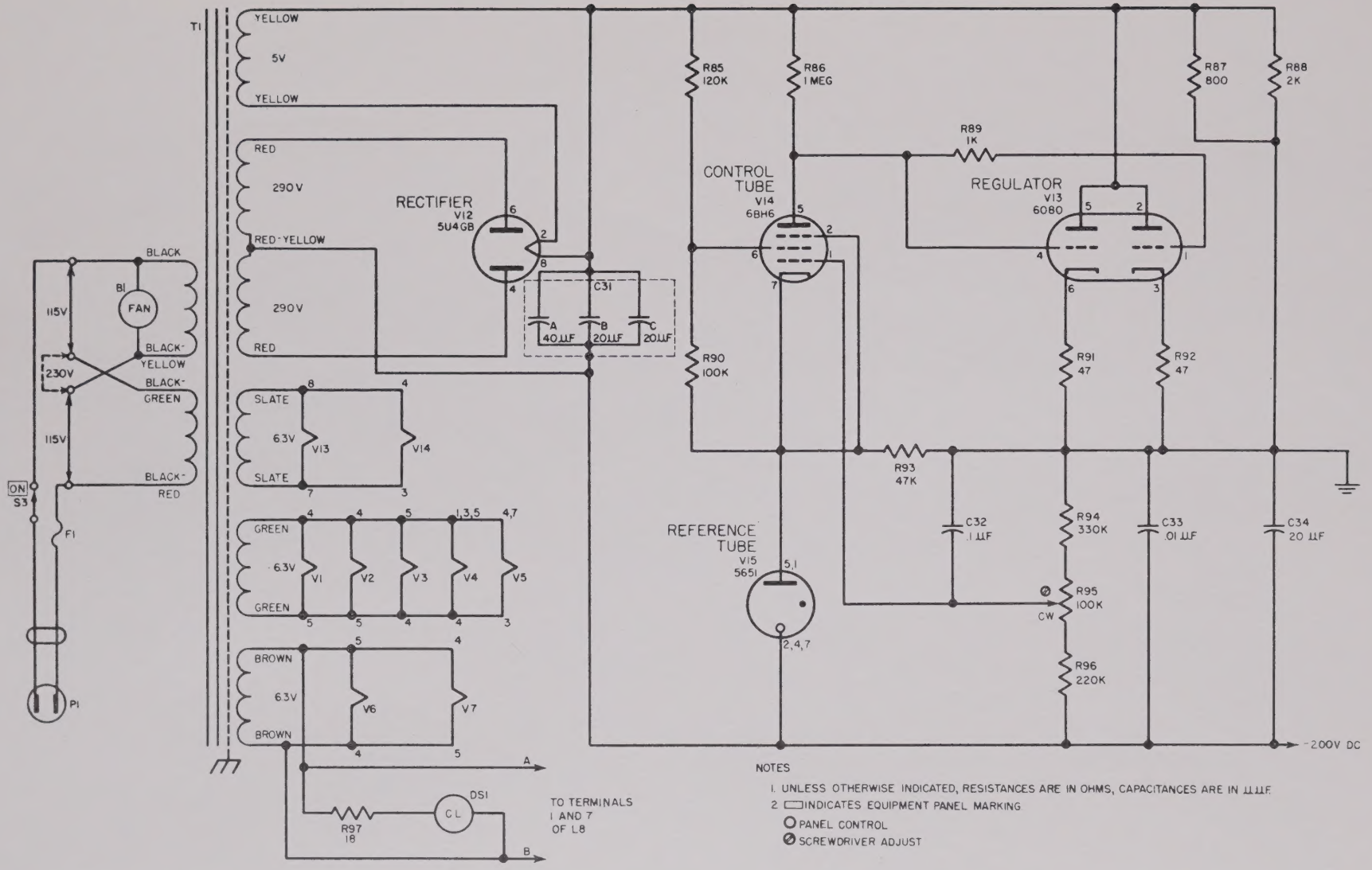


Fig. 5-C Schematic Wiring Diagram